170-160.18

416/49

PUBLISHED
MAY 18, 1943.
BY A. P. C.

E. FLORIAN ET AL
VARIABLE PITCH AIR PROPELLER
Filed July 12, 1940

Serial No. 345,132

4 Sheets-Sheet 1

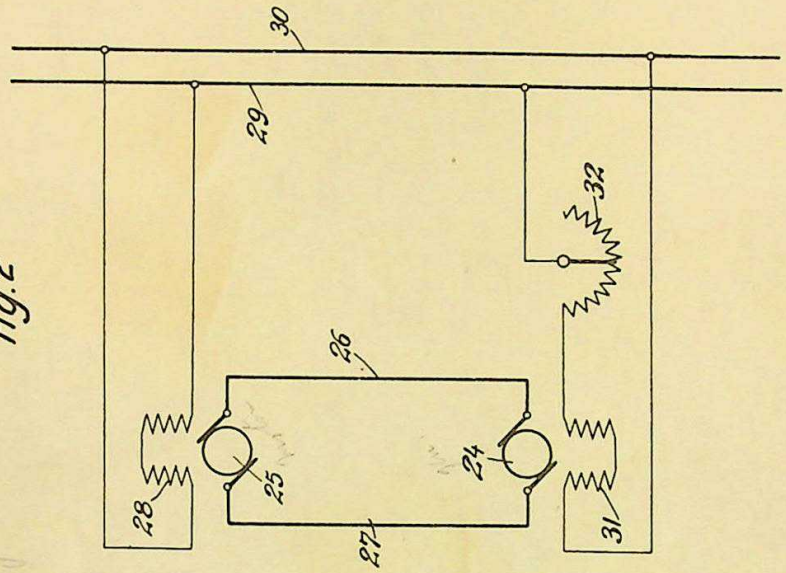

Fig. 2

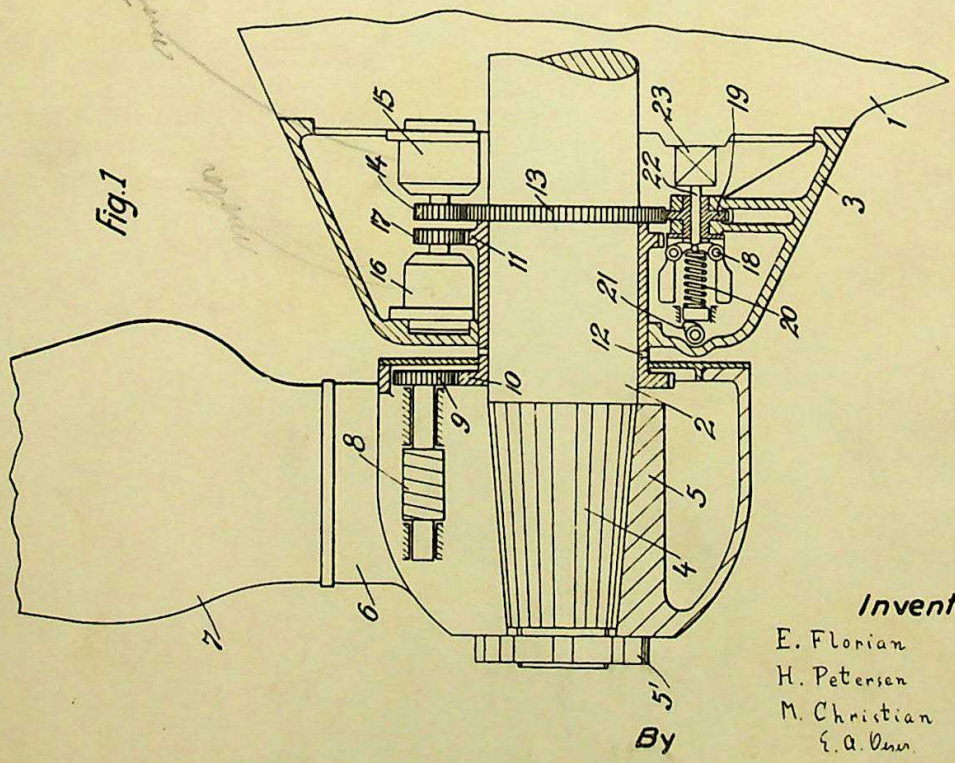

Fig. 1

Inventors
E. Florian
H. Petersen
M. Christian
E. A. Ohm
By
Agent

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Fig. 4

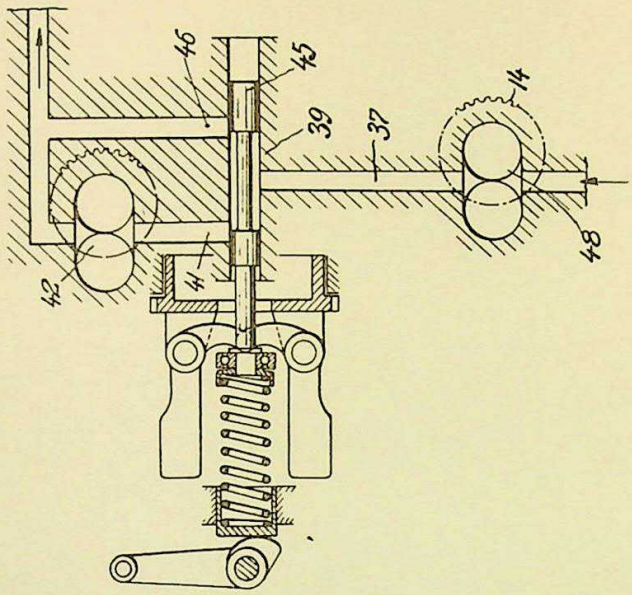
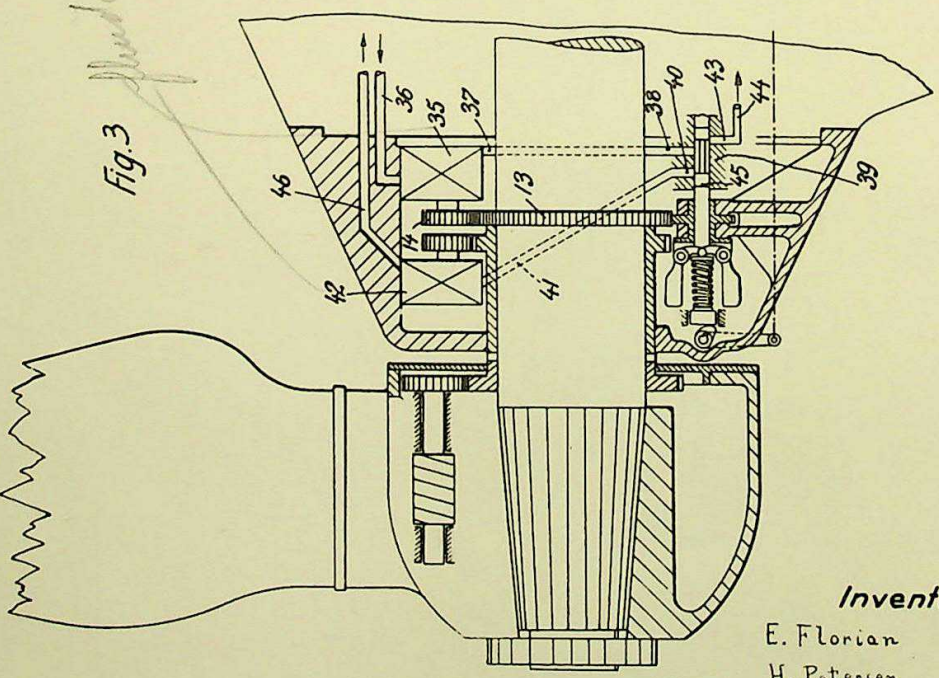


Fig. 3



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E. Florian
H. Petersen
M. Christian
By E. A. Ohm.
Agent

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Fig.5

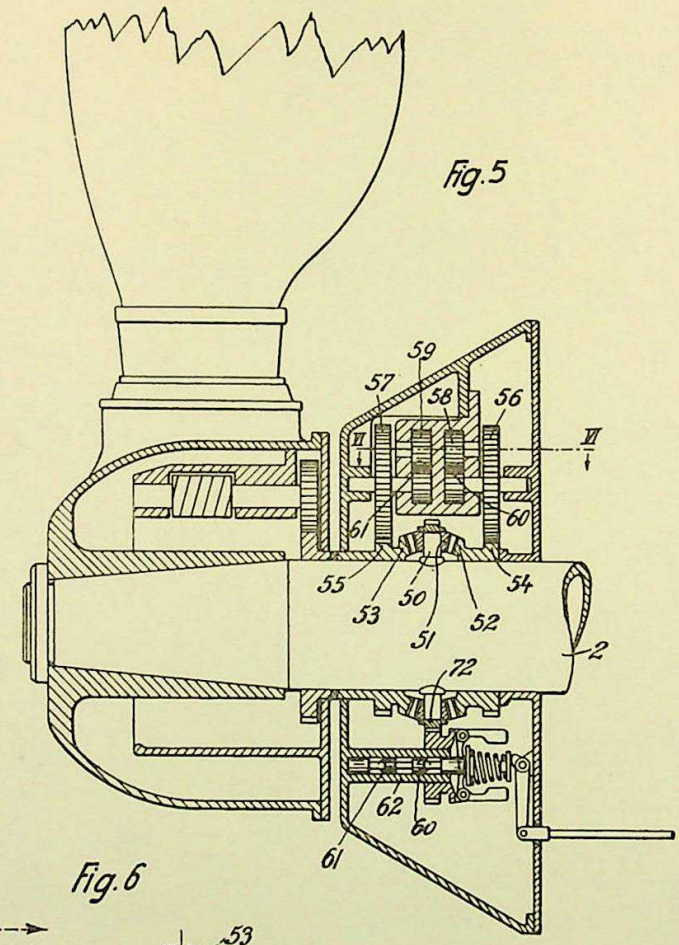
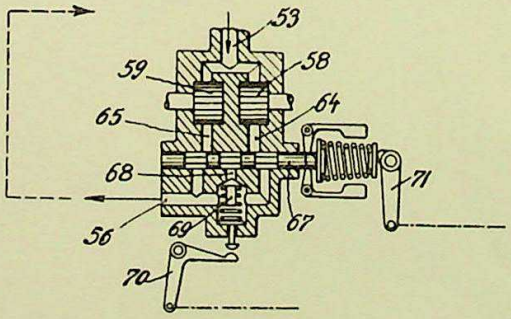


Fig.6



Inventors
E. Florian H. Petersen
M. Christian
By
G. A. Ohm
Agent

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BY A. P. C.

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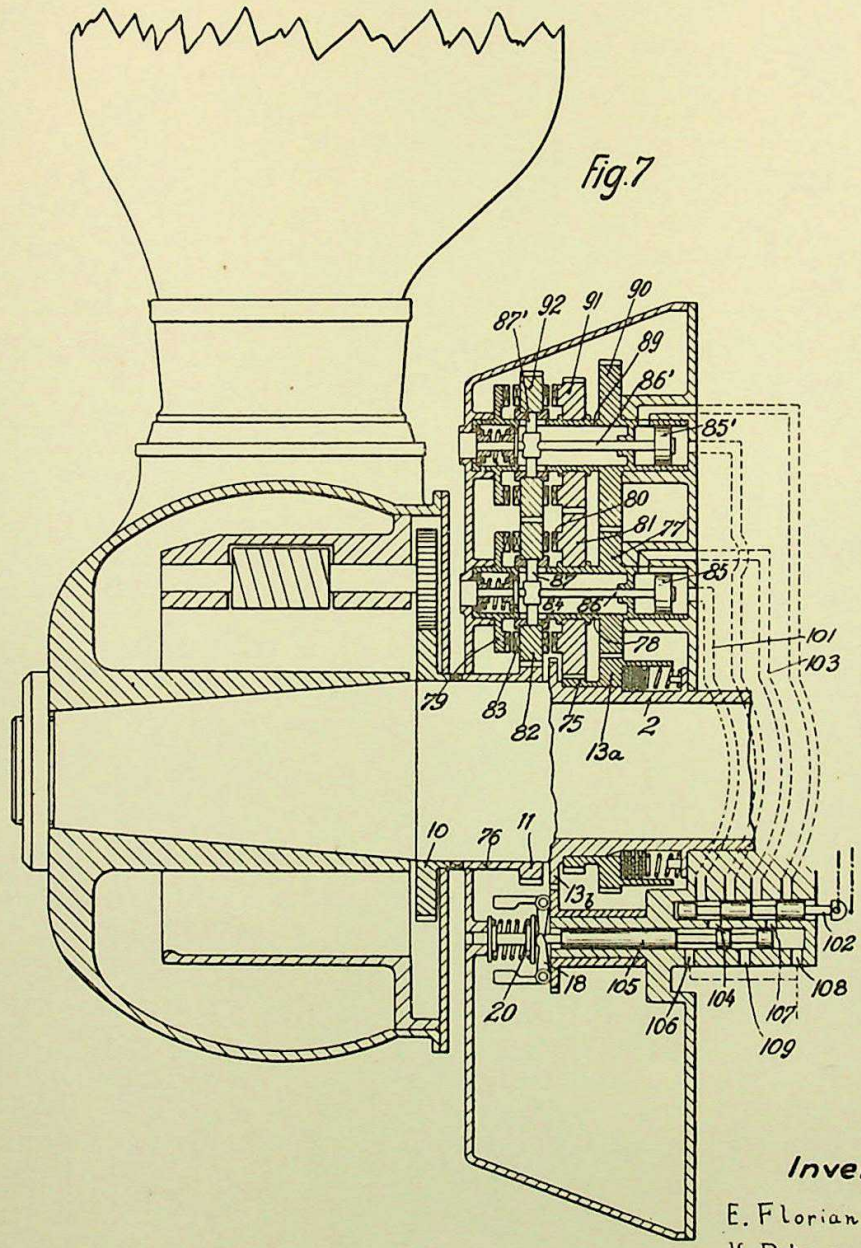

Inventors
E. Florian
H. Petersen
M. Christian
By
Agent

Published May 18, 1943

Serial No. 345,132

ALIEN PROPERTY CUSTODIAN

VARIABLE PITCH AIR PROPELLER

Ernst Florian and Heinrich Petersen, Berlin-Reinickendorf-Ost, and Manfred Christian, Berlin-Dahlem, Germany; vested in the Alien Property Custodian

Application filed July 12, 1940

The present invention relates to variable pitch air propellers in which the position of the blades is altered by a gear arranged in the hub, said gear being driven by a hollow shaft surrounding the shaft of the air propeller.

In the first developed automatic variable pitch air propellers this was effected by the use of centrifugal weights which were connected to the propeller blades. A definite position of the centrifugal weights corresponded to a definite position of the blades and the power for adjusting the blades was supplied by the centrifugal weights themselves. With higher motor outputs, however, the power required for adjustment will be so large that an auxiliary device for supplying the power necessary for the adjustment of the blades will be required while the centrifugal weights act as a centrifugal governor only controlling the auxiliary power for adjusting the propeller blades.

Hitherto the auxiliary power for instance has been obtained by arranging in front of the propeller a blade wheel driven by the relative air current or by arranging upon the hub of the propeller an electromotor which was supplied with current by means of slip rings.

All these known devices, however, have the drawback that a rather complicated construction is required if a limitation of the adjustability to a few steps only is not included in the bargain, but a stepless adjustment if possible as far as to the fathering- or idle running position is to be obtained. The interior of the propeller hub which itself is rather difficult to manufacture is provided with cross walls, bearings and other irregularities in the form and in the hub a gear drive is provided having a large number of gears as well as a corresponding large number of individual elements. This considerably increases the weight of the total propeller and calls into question the entire reliability of service.

The present invention is concerned with a stepless automatically operating variable pitch propeller in which for the adjustment of the blades an auxiliary power is used, whereas a centrifugal governor controls the auxiliary power only. The object of the present invention is to considerably simplify the construction, particularly the construction of the hub.

In connection with variable pitch propellers used for driving vessels or boats it is already known to arrange in the hub of the propeller a gear acting upon the rotatably mounted feet of the blades, to effect, however, the drive of this gear by a hollow shaft surrounding the propeller shaft. With this known construction, however, the adjustment could only be effected by arbitrary operation by hand, for which purpose the hollow shaft had to be axially displaced. The problem of automatic stepless adjustment of the propeller blades was, therefore, not solved by this construction.

According to the present invention the problem in question is solved mainly by the fact that for producing the movement of adjustment a stationary device driven by the shaft of the propeller itself is provided. This adjustment device, therefore, is an additional constructional part arranged outside the hub, whereby the manufacture of the hub is very simplified and the weight thereof considerably reduced. A further advantage results from the fact that the device for producing the power of adjustment is no longer subjected to the centrifugal weights and, therefore need not be balanced absolutely exactly. The control of the device supplying the power of adjustment preferably is effected by a centrifugal governor.

Further features and advantages of the invention result from the following specification and the accompanying drawings.

In these drawings:

Fig. 1 shows a diagrammatic cross section through a first construction provided with an electrically operated adjusting device,

Fig. 2 is a diagram of the connections of the adjusting device of the modification shown in Fig. 1,

Fig. 3 shows a second modification provided with a hydraulically operated adjusting device,

Fig. 4 shows diagrammatically and on a larger scale details of the modification illustrated in Fig. 3,

Fig. 5 shows a further modification provided with a mechanically operated adjusting device,

Fig. 6 is a section on line VI—VI of Fig. 5, and

Fig. 7 shows a further modification partly in section.

In all the figures the front end of an aircraft motor having an adjustable pitch propeller is shown. To simplify the understanding of the invention such details only are described and provided with reference characters which are directly connected to the invention.

Flanged to the motor casing 1 is a casing 3 surrounding the shaft 2 of the air propeller. By means of a nut 5′ the hub 5 of the air propeller is fixed upon the cone 4 of the propeller shaft 2. In lugs or projections 6 of the hub of the propeller the propeller blades 7 are rotatably mounted in a manner known per se. At the foot of the propeller blade 7 a worm 8 engages a toothed ring not

shown in the drawings and provided at the foot of the propeller blade. Mounted upon the one end of the worm 8 is a gear wheel 9 engaging with a gear wheel 10 rotatably mounted upon the shaft 2. By means of claws 12 the hub of the gear wheel 10 is coupled to the hub of a gear wheel 11 also rotatably mounted upon the shaft 2. Adjacent the gear wheel 11 a gear wheel 13 is fixed upon the shaft 2 and this gear wheel 13 engages a gear wheel 14 arranged upon the shaft of a dynamo-electric machine 15 mounted at the motor casing 1. Opposite the dynamo-electric machine 15 the electric driving motor 16 is mounted in the casing 3 and with the armature of this motor 16 the gear wheel 17 rotates which engages the gear wheel 11 mounted upon the shaft 2.

For the control of the adjustment a centrifugal governor 18, driven in dependence on the number of revolutions of the motor, is provided. This governor is driven in a well known manner by means of its gear wheel 19 by the gear wheel 13 fixed upon the shaft 2. The governor spring 20 may be influenced by way of the rotatable cam 21 by hand or by another control member so that the resistance, offered to an alteration of the position of the centrifugal weights, may arbitrarily be altered. The control rod 22 which may axially be displaced by the centrifugal weights acts upon the electric governor 22 which preferably is constructed as a shunt governor.

The operation of the described device is as follows:

If the shaft 2 rotates the dynamo-electric machine 15 is driven by means of the gear wheel 13 and the gear wheel 14 engaging with the wheel 13. The dynamo-electric machine 15 is connected by way of electric conductors to the driving motor 16, the gear wheel 17 of which, connected to the armature, engages with the gear wheel 11. The latter may freely rotate about the shaft 2 and is, by means of the clutch 12 connected to the gear wheel 10 with which the gear wheel 9 is in engagement. The wheel 9 drives the worm 8 which, on being rotated, adjusts the blade 7 by way of a worm wheel not shown in the drawings and arranged at the foot of the blade. Corresponding driving means are provided for the other blades also.

The electrical arrangement is such that at a definite number of revolutions of the motor the dynamo-electric machine 15 and the motor 16 driven by the latter are rotated with the same number of revolutions. If with the chosen same ratio of gearing between the wheels 13 and 14 as well as the wheels 11 and 17 the driving motor 16 is rotated with the same number of revolutions as the dynamo-electric machine 15, the wheel 11 is rotated but does not revolve relatively to the shaft 2. Consequently, the worm 8 is not driven and the propeller blade maintains its position. If now, in any desired manner the number of revolutions of the driving motor is altered with regard to that of the dynamo-electric machine the wheel 11 rotates with regard to the shaft 2 and the gear effecting the adjustment of the propeller blade 7 is rendered operative. If the motor runs faster than its driving machine then the gear wheel 11 leads with regard to the shaft 2. If, however, the motor runs slower than its driving machine then the gear wheel 11 lags. Hereby the air propeller blade 7 is rotated in another sense, i. e. in a sense of increase or decrease of the pitch angle.

The alteration of the number of revolutions of the driving motor relatively to that of the dynamo-electric machine preferably is effected in a well known manner by an electric shunt governor 23, for instance by the use of the Leonhard-connection. For this purpose preferably the centrifugal governor 18 with the governor rod 22 is used, which governor by way of the governor spring may be influenced by hand or by other control means.

Fig. 2 shows the use of the well known Leonhard-connection for the control arrangement of the air propeller. The armature 24 of the dynamo-electric machine is by way of the conductors 26, 27 short-circuited with the armature 25 of the driving motor. The field winding 28 of the motor is connected to the mains 29, 30 only, while in the circuit of the field winding 31 of the dynamo a shunt governor 32 is connected. By means of this well known connection not only a very exact control of the number of revolutions of the motor but also such a control extending over a large range may be effected.

In the construction shown in Fig. 3 the electrical adjusting device illustrated in the modification just described is replaced by a hydraulic device.

In this case the gear wheels 13 and 14 serve for driving an oil pump which for instance is provided with a suction pipe 36 leading from the oil sump of the motor and with a feed pipe 37 which discharges into the control channel 38 of the control casing 39. From the control cylinder arranged in the casing 39 the pressure pipe 41 leads to a pressure oil motor 42 by way of the control channel 40.

Compared with the pressure oil motor 42 the oil pump 35 is so dimensioned that the amount of oil under pressure supplied is sufficient to drive the motor 42 with a number of revolutions which is higher than its own number of revolutions. If the air propeller blades are to maintain their position then with the same ratios of gearing synchronism of the oil pump 35 and of the pressure oil motor 42 is to be taken for granted. This is obtained by throttling a portion of the oil under pressure at the entrance into the control channel 40 whereby simultaneously a corresponding amount of oil under pressure is discharged by the channel 43 of the discharge pipe 44. It may sometimes also be preferable to use a single control opening corresponding to the channel 43 only, whereas the control channels 38 and 40 are permanently connected to each other by the cylinder in which moves the control slide 45.

The spent oil of the motor 42 returns by way of the discharge pipe 46 to the oil tank, preferably to the oil sump of the motor, in order to be used again.

Fig. 4 shows on a larger scale a special construction of the control device arranged between the oil pump and the pressure oil motor. 48 is an oil pump, for instance of the kind of a gear pump, provided with a driving wheel 14. This pump supplies oil under pressure by way of the pipe 37 into the control cylinder 39 in which the distribution towards the control channel 41 and the discharge pipe 46 is effected by means of the control slide 45. If shifted as far to the left as possible, the slide 45 completely opens the channel 41 leading to the pressure oil motor 42, the overflow channel 46 simultaneously being closed. In accordance with the displacement of the cylinder towards the right under the action of the centrifugal governor or other control members, for instance by hand, throttling is effected at the channel 41, whereas simultane-

ously the overflow opening 46 is correspondingly opened. In this manner the motor 42 may with regard to its number of revolutions be so controlled that the members effecting adjustment of the air propeller blade start moving in the one or the other sense.

Figs. 5 and 6 show a further modification according to which the drive of the members effecting the adjustment directly is obtained mechanically by way of a differential gear, each of the members engaging the differential wheels being controlled by an oil pressure brake associated therewith.

Upon the air propeller shaft 2 a plurality of bevel gear wheels 51 is mounted upon stationary bolts 50 and bevel gear wheels 52, 53 rotatably mounted upon the shaft 2 engage with these bevel gear wheels 51. These two bevel gear wheels 52, 53 are connected with a toothed rim 54 and 55 respectively. The toothed rim 55 is connected in the manner described above with the adjusting gear mounted in the air propeller hub. By way of spur wheels 56, 57 the spur wheels 54, 55 drive the spur wheels 58, 59 of two oil brakes constructed in the manner of gear wheel pumps. This control and regulating device preferably is directly connected to the oil brakes and the two devices are shown separated from each other in Fig. 5 for the sake of clearness only.

Fig. 6 shows in a section on line VI—VI of Fig. 5 a construction of the above mentioned brake device with governor and control by hand. The oil brakes 58 and 59 are, by way of a pipe system 63, supplied with oil from storage tanks not shown in the drawings or from the oil sump of the motor. The oil flows through the conduits 64, 65 and through the control cylinder into the collecting pipe 66 and back again through an oil cooler into the storage tank. Only if the control slide 67 occupies the centre position shown in Fig. 6 may the oil flow without resistance being offered. If the slide 67 is shifted for instance towards the left, then the oil must flow from the channel 65 into the channel 68 in which an overpressure valve 69 or a nozzle is arranged. The resistance of this valve acts upon the adjusting gear 57 and 55 in the manner of a brake so that a relative movement between the shaft 2 and the gear wheel 55 occurs. If the slide 67 is shifted towards the right, the brake 58 mounted at the right-hand side comes into operation. The resistance of the valve 69 may be altered in a simple manner by the lever 70 acting upon the valve spring and adapted to be affected by hand or by special control means. The lever 70 may also be adjusted together with the lever 71 belonging to the centrifugal governor.

By adjusting the lever 70 controlling the loading of the valve cone 69 a change from slow gear to fast gear may be effected. Preferably, besides the adjustment to ordinary adjusting speed an adjustment for higher adjusting speed is provided. If instead of the valve 69 a nozzle is provided then the opening of the nozzle and thereby the resistance thereof may be altered by adjustment.

The operation of the device is as follows:

If the motor runs with a constant number of revolutions and if there is no reason for altering the position of the propeller blades, both oil brakes run idle, i. e. the oil sucked in and fed by both oil brakes flows in a circuit without appreciable resistance being offered thereto. If by means of the control slide 67 the stream of oil is throttled at the left- or right-hand side, then a brake action occurs by which for instance the wheel 55 rotating hitherto with the number of revolutions of the shaft 2 is caused to run slower and to act upon the position of the blades by way of the adjusting gear. If, however, a braking action is applied to the gear wheel 54, the relative movement is, by way of the planet pinions 51, transferred upon the adjusting gear in a reverse sense of rotation. In this manner the blades may selectively be rotated in the one or the other sense by hand or automatically by the centrifugal governor. The number of revolutions of the governor depends on the number of revolutions of the motor. In Fig. 5 the driving wheel 72 of the governor is fixed upon the bolt 50 of the planet pinions.

In the modification shown in Fig. 7 the power derived from the motor shaft 12 is directly used for adjusting the air propeller without employing the power transformers described in connection with some of the above modifications which transform the power occurring first as rotary movement into pressure or electric power which in turn is transformed into rotary movement. Nevertheless, in the modification according to Fig. 7 also the main inventive idea is reduced to practice, i. e. a stationary device driven by the air propeller shaft itself is provided for automatically producing the adjusting movement.

As in the modifications already described in this case also the means for driving the centrifugal governor 18 is a toothed rim 13*a* mounted upon the air propeller shaft 2 which, however, in the present case has a second toothed rim 75. The drive of the governor is effected in the same manner as described in connection with the other construction but a special toothed rim 13*b* directly mounted upon the air propeller shaft 2 is provided adjacent the toothed rim 75. These two drive gears act upon two groups of back gears which are independent on each other and may selectively come to action. The purpose of arranging two back gears is to allow the adjustment of the air propeller blades with various speeds. For special cases a quick adjustment of the blades seems to be necessary. For the normal operation of the adjusting gear in dependence on the automatically operating governor such a quick adjustment, however, has the drawback that an "overcontrol" of the blades may occur, i. e., that an adjustment once initiated is continued if the automatically operating governor is again in its state of equilibrium. By a slower adjustment of the blades which is possible in this modification by the special second back gear such an overcontrol is prevented.

Below the back gear for the fast gear of the adjusting device will first be described:

A gear wheel 77 the opposite end of the shaft 78 of which is rigidly connected to the clutch disc 79 engages the gear wheel 13 mounted on the main shaft 2. Rotatably mounted upon the shaft 78 is a gear wheel 81 provided with claws 80. Between the latter and the disc 79, also provided with claws, a gear wheel 82 is axially displaceably mounted upon a sleeve 84. The gear wheel 82 carries claws 83 at both sides and engages with the gear wheel 11 to which the wheel 10 is coupled in the manner already described.

The gear wheel 82 is connected to a pressure piston 85 arranged in the interior of the hollow shaft 78. For this purpose the piston rod 86 is provided with a cross rod 87 movably arranged in

slots of the shaft 78. The cross rod 87 extends through the sleeve 84 and carries the same with it when being axially displaced. The piston 85 is operated by oil under pressure in a manner to be later described and is influenced by a control slide. Preferably, the piston 85 is, by means of springs, maintained in its middle position as long as the oil pressure acting upon one side of the piston does not cause displacement of the piston into another position. If now the control causes shifting of the gear wheel 82 towards the left, then the claws 83 engage with the corresponding claws provided at the clutch disc 79, i. e. the wheel 82 is rotated with the same speed as the gear wheel 77. The ratio of gearing between the gear wheel 13 mounted upon the shaft 2 of the air propeller and the gear wheel 77 arranged upon the shaft 78 of the back gear and, moreover, the ratio of gearing between the gear wheel 82 and the gear wheel 11 are so chosen that the latter as well as the adjusting gear wheel 10 rotate somewhat faster than the main shaft 2. This adjustment of the clutch results in an adjustment of the blades of the air propeller in a definite sense. The opposite adjustment of the blades of the air propeller is obtained by displacing the piston 85 by means of its hydraulic control towards the right until said piston reaches the end of its stroke. Hereby the claws 83 of the gear wheel 82 come into engagement with the claws 80 of the gear wheel 81. The ratio of gearing between the gear wheel 75 arranged upon the main shaft 2 and the gear wheel 81 of the back gear is so chosen that the wheel 11 rotates slower than the main shaft 2. Hereby an adjustment of the propeller blades in an opposite sense is effected by way of the adjusting gear wheel 10.

The second back gear serving for the slow adjustment is constructed in the same manner as the first back gear already described except that the diameters of the corresponding gear wheels are chosen differently. The gear wheel 90 arranged upon the shaft 89 of the second back gear is connected to the gear wheel 77, mounted on the shaft 78 of the back gear, and thereby to the gear wheel 13. Moreover, the gear wheel 91 is connected to the gear wheel 81 and thereby to the gear wheel 75. Finally, the gear wheel 92 is connected to the gear wheel 82 and thereby to the gear wheel 11. The axial displacement of the gear wheel 92 provided with lateral coupling claws is effected by corresponding parts, as for the gear wheel 82, that is to say, by the piston 85′ with the piston rod 86′ and the cross rod 87′.

As mentioned already, the axial displacement of the wheels 82 and 92 effecting the coupling either for a high pitch or for a low pitch is obtained by hydraulic actuation of the pistons 85 and 85′. Hydraulic means have already been used in connection with variable pitch propellers. Hereby in most cases the difficulty is to overcome that the hydraulic means is to be supplied under pressure from a stationary portion of the aircraft into a revolving portion, for instance the hub. This difficulty does not exist with the construction according to the present invention, because the entire adjusting device is stationary so that the hydraulic means need be conducted through stationary pipes only which easily may be sealed.

As the two pistons 85 and 85′ for shifting the two back gears are identical, the description of the hydraulic control of the piston 85 only will be sufficient. Leading into the cylinder space provided in the drawing at the right-hand side of the piston 85 is a conduit 101 which discharges into a cylinder in which the control slide 102 is provided. From the cylinder space at the left of the piston 85 a conduit 103 leads to the same cylinder of the control slide 102. In the position of the control slide 102 shown in the drawing the conduit 101 is by way of a passage 104 connected to a cylinder space in which the control slide 105 is provided. From this cylinder a further connection to a passage 106 is provided which allows the discharge of the hydraulic medium, for instance oil under pressure.

The conduit 103 is connected by way of the cylinder containing the control slide 102 to a passage 107 which leads into the cylinder of the control slide 105. In the position of the control slide 105 shown in the drawings, a connection between the passage 107 and the passage 108 representing the discharge of the oil under pressure is possible.

Into the cylinder of the control slide 105 discharges a passage 109 by which oil under pressure is supplied.

The control slide 102 is arbitrarily adjusted by hand, whereas the control slide 105 is actuated by the centrifugal governor 18. By means of the slide 102, therefore, either the back gear provided with the piston 85 and serving for the fast adjustment of the back gear provided with the piston 85′ and serving for the slow adjustment may be rendered operative. The axial displacement of the clutch-gear wheels 82 and 92 respectively and thereby the adjustment of the blades of the air propeller to higher or lower pitch is effected in a manner known per se by the fact that the centrifugal governor controls the slide 105 and thereby allows the supply of oil under pressure either into the space provided adjacent the right-hand side or at the left-hand side of the piston 85 and 85′ respectively.

The oil under pressure used for effecting the switching or shifting movements may be derived from any desired source, for instance also from the motor oil pump.

In the construction shown the shifting or switching of the gear is effected by a servo-motor, because thereby the centrifugal governor 18 is released from the forces necessary for effecting the shifting or switching movements and has to cause only the movement of the control slide 105. Of course, the shifting or switching could be effected without the use of the servo-motor also, that is to say, directly by the centrifugal governor.

All the above described modifications are characterized by a very simple construction of the hub of the air propeller and by a resistivity and a perfectly reliable construction of the elements which produce the power necessary for the adjustment, control, transform and transfer this power from the stationary adjusting device upon the hub and the feet of the propeller blades. The assembling and the exchange of the individual members may easily be effected and even most drastic alterations of the operating conditions, as for instance of the temperature, humidity of the air or the like have no effect whatever. As far as electric devices are employed, the use of slip rings and similar unreliable parts subjected to wear has been rendered superfluous.

ERNST FLORIAN.
HEINRICH PETERSEN.
MANFRED CHRISTIAN.